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Use of Honey Bees in Alfalfa Seed Production

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INTRODUCTION

Pollinating insects are necessary for the production of alfalfa seed, but their exact role has never been clearly understood. Most agronomists now maintain that the alfalfa flower has to be both tripped and cross-pollinated if an appreciable amount of seed is to result, and that insects are the principal agents for both. It has been known for some time that certain wild bees are efficient trippers of alfalfa and as such are also good cross-pollinators. Honey bees (*Apis mellifera* L.) have not been thought to be important trippers of alfalfa, since most of those seen working in the fields apparently obtain nectar from the blossoms without tripping them, and thus not exposing the stamens and stigma so that they can be pollinated.

An acre of alfalfa may contain several hundred million blossoms. The job of pollinating it is therefore a large one. Failure in the past to do anything about pollination, such as providing for the presence of pollinating insects, is partially responsible for the long-standing decline in the per-acre production of alfalfa seed. Moreover, populations of wild pollinating insects have been reduced by various agricultural practices, such as plowing and cultivating the soil and the use of insecticides. Most of these insects are ground nesting or make their nests in hollow reeds close to the ground, where they are easily destroyed by many modern farm operations. In recognition of this fact and the necessity for providing pollinating insects in abundance, attempts have been made to use honey bees to make up the deficiency.

[1] In cooperation with the University of California.

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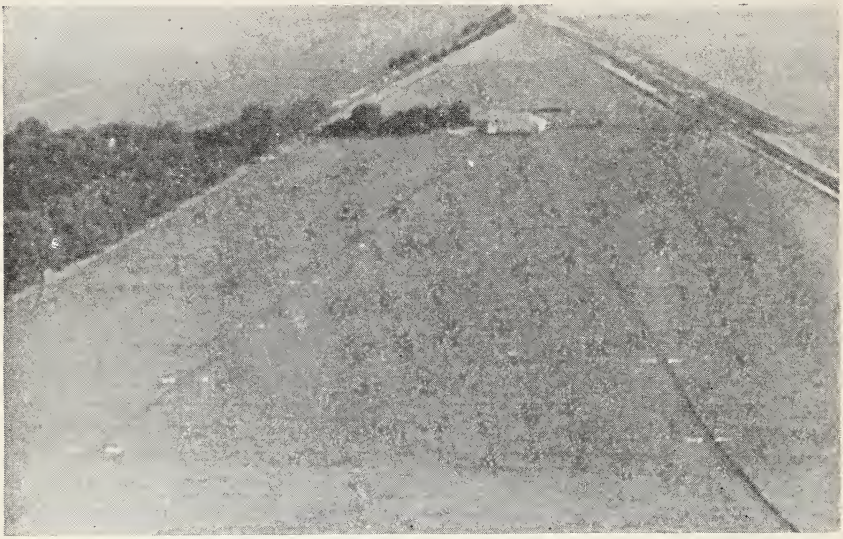

Aerial view of honey bee colonies in groups of 12 along two drives across a California alfalfa-seed field. Six colonies were set down on each side of the truck that delivered them to the field.

Until the last 2 or 3 years moving honey bees into alfalfa fields to increase seed production was almost unheard of, although it was common practice to place bees in or near the fields at blooming time for the sole purpose of obtaining honey. Research conducted during the last few years has revealed more clearly the role of honey bees and pointed out the possibilities for increasing seed production through their use.[2]

It should be borne in mind, of course, that pollination by insects is only one of the requirements for production of alfalfa seed. For maximum seed crops, various agronomic practices must be followed to obtain good stands of vigorous growing plants. Injurious insects, of which the lygus bug is the most important, if not controlled are capable of destroying the buds and blossoms to such an extent that a seed crop is not possible. Plant diseases, soil moisture and fertility, weather conditions, varieties of alfalfa, methods of seed harvesting, and many other factors also affect seed production.

The use of honey bees for pollinating alfalfa poses new problems not only to the grower of alfalfa seed but to the beekeeper. The grower's problem is to get the bees; that of the beekeeper is to learn how to manage them when they are used for pollination rather than for the production of honey.

This circular describes how colonies of honey bees have been used under western conditions to increase seed production in alfalfa and points out some of the problems involved in doing so.

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[2] Many experiment-station workers, alfalfa-seed growers, and beekeepers in the Western States cooperated in this research. Among the technical workers who have helped through the years are L. G. Jones and J. F. Reinhardt in Davis, Calif., F. E. Todd in Tucson, Ariz., and J. W. Carlson and F. V. Lieberman in Logan, Utah.

FACTORS INFLUENCING ACTIVITY OF BEES IN ALFALFA

The activity of bees on alfalfa flowers is affected by the weather and soil moisture, by the variety and condition of the alfalfa, by the proximity to other kinds of plants in blossom at the same time, and by the use of insecticides in alfalfa or neighboring fields.

Weather and Soil Moisture

Low temperatures, strong winds, cloudiness, and rain retard bee flight. During such weather there is little pollen or nectar gathering by either wild or honey bees. The dry climate of the West is therefore favorable for field work by bees.

The amount of soil moisture affects the growth and blossoming habit of alfalfa and therefore its seed-yielding capacity. With a moderate supply of moisture the plants grow large and produce many blossoms over a long period, and the seed pods mature slowly so that the seeds become large. Under drought conditions the plants will not grow or blossom satisfactorily and few of the pods mature. Excess soil moisture, however, causes too rapid vegetative growth.

The amount of soil moisture during the blooming period affects also the sugar concentration of the nectar. Honey bees generally select nectar of highest sugar content. Of plants grown side by side in a greenhouse and subjected to different amounts of soil moisture, the sugar concentration decreased with increasing amounts of moisture (Vansell 7). Many samples of nectar collected by bees from fields on comparatively moist soil in various localities have been low in sugar content. In June 1939 a field of alfalfa growing on loamy soil at Davis, Calif., was heavily irrigated. Bees working in the field 10 days later carried nectar with an average sugar content of 34 percent, but nectar collected from moderately dry fields had more sugar. At Brawley, Calif., the nectar from one alfalfa field, where the soil was dry and cracked and the semidry plants had the characteristic grayish-green color, had a sugar concentration of 63 percent, but nectar from another field, irrigated 3 days before, averaged 29 percent of sugar.

Pollen-collecting bees also prefer plants grown in moderately dry soil. Of two adjacent fields near Delta, Utah, that had been planted from the same lot of seed but only one had been recently irrigated, in 1 day the bees tripped 59 percent of the blossoms in the dry field but only 13 percent of those in the irrigated field. Of course, other factors more obscure than soil moisture could have contributed to this difference.

A large field near Davis, Calif., was irrigated several times, but different parts of the field received different amounts of water. The seed yield in this field ranged from 400 to 1,300 pounds per acre, in proportion to the amount of water received. Since the population of nectar-collecting bees was high, averaging 3 or 4 per square yard, and the control of weeds and lygus bugs was good, the moisture was the main factor determining the yield.

Variety of Alfalfa

When two varieties of alfalfa are grown near together, one variety often seeds better than the other. Apparently the varieties differ in attractiveness to bees, with consequent differences in pollination. In northern Utah a few wild bees were seen repeatedly to search out and trip nearly all the blossoms on a group of 4 clones of one variety growing without irrigation in a plot of 15 varieties. At Davis, Calif., in September 1947 honey bees tripped 41 percent of the flowers of Utah Common and 30 percent of the Ranger flowers when the two varieties were grown under irrigation in alternate rows. Daily tripping records for 2 weeks showed a consistently similar trend.

Plant Competition

Honey bees collecting pollen ignore alfalfa if plants that they prefer are in bloom in the vicinity. To collect pollen from alfalfa they must trip the flowers, and the amount of pollen in one flower is comparatively small. The following plants are easily worked for pollen and in the West may blossom concurrently with alfalfa (Oertel *6*) :

Alsike clover (*Trifolium hybridum* L.)
Asparagus (*Asparagus officinalis* L.)
California poppy (*Eschscholtzia* or *Papaver* spp.)
Canada thistle (*Cirsium arvense* (L.) Scop.)
Carrot (*Daucus carota* L.)
Chicory (*Cichorium intybus* L.)
Gumweed (*Grindelia* spp.)
Mustard (*Brassica* spp.)
Spikeweed (*Centromadia pungens* T. and G.)
Sweetclover (*Melilotus* spp.)
Vetch (*Vicia* spp.)
White clover (*Trifolium repens* L.)
Wild radish (*Raphanus sativus* L.)
Yellow star-thistle (*Centaurea solstitialis* L.)

Near Logan, Utah, sweetclover, gumweed, Canada thistle, and chicory were abundant in 1944, and the honey bees collected pollen from them. Pollen traps placed on beehives in this locality were nearly free of alfalfa pollen. On the other hand, in a desert area near Delta, Utah, where there are few good sources of pollen, honey bees freely collected pollen from alfalfa. Pollen traps operated in six locations in Utah in 1944 yielded samples containing from 17 to 80 percent of alfalfa pollen (Hare and Vansell *3*).

In Arizona and the interior of southern California alfalfa is an excellent source of honey and is the basis of one of the most extensive beekeeping operations in the West. The production of alfalfa seed has also been successful because the bees collect pollen as well as nectar. Moreover, in the arid climate of these areas a field quickly dries out. At Phoenix, Ariz., 10 pounds of almost pure alfalfa pollen were trapped on two beehives during May and June of 1940. At Brawley, Calif., 42 percent of the bees caught in a field in June 1939 were carrying alfalfa pollen.

At Hemet, in Riverside County, Calif., a decided increase in the tripping activity of honey bees on alfalfa was noted after a field of mustard had been clipped (Linsley and MacSwain *5*).

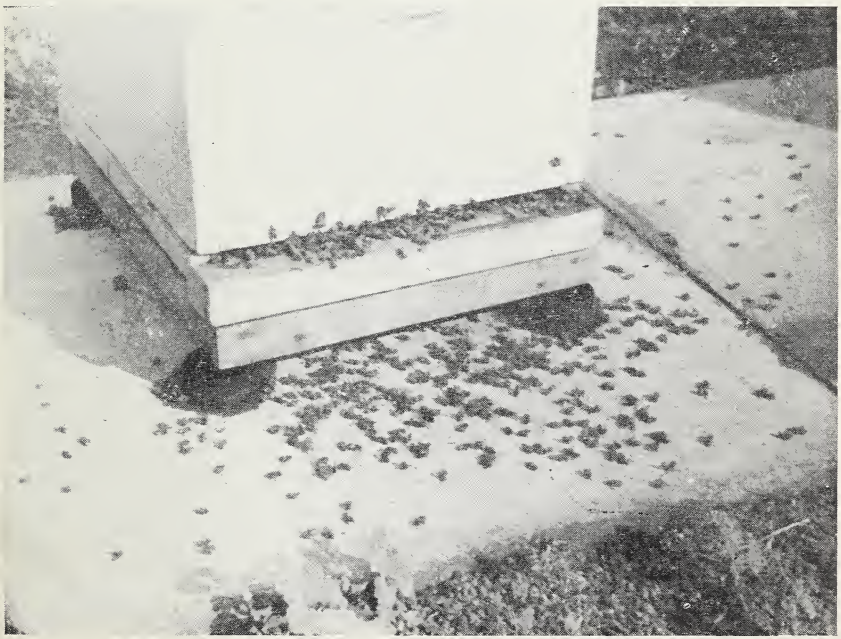
Crop management to reduce competition from other plants while alfalfa is in bloom is important where this crop is grown for seed. The practice should not be carried too far, however, because bees require pollen and nectar from various plants grown over a long period.

Insecticides

Insecticidal practices that destroy bees cause losses to both seed growers and honey producers. Dusting or spraying with arsenicals is extremely hazardous to bees.

The use of DDT to control lygus bugs and other insects may affect bees favorably or unfavorably. Its timely use has greatly increased the number of blossoms in some fields. Nectar secretion may also be greater in plants free from injurious insects. On the other hand, DDT kills bees. In the Delta section of Utah many bees were killed in 1946 by extensive dusting of alfalfa fields with 10-percent DDT while they were in full bloom. In 1947 most of the dusting was done when the plants were in the prebloom stage, and the dusting that was necessary during the blossom stage was done largely at night or early in the morning. Honey bee losses were thus reduced in this important seed area. A poor honey crop was harvested in 1946, but in 1947 the yield per colony was the largest in 10 years.

Recent investigations in Utah (7) show that lygus bugs on seed alfalfa can be controlled by the properly timed use of certain insecticides without needlessly destroying domestic and wild bees that pollinate the flowers. DDT is recommended when the alfalfa is in bud. When reinfestation warrants a second treatment 3 to 4 weeks later, toxaphene is recommended, with the provision that it be applied only after 7 p. m. or before 7 a. m., when bees are not visiting the flowers.



Dead honey bees at the entrance to a scale hive at Davis, Calif., in July, killed by calcium arsenate dusted on tomato fields nearby. All the bees were dead by September. (Photograph by A. W. Woodrow.)

Not only does DDT kill the bees working alfalfa blossoms, but the dusted areas may be almost devoid of new bee visitors for several days thereafter. This effect has been observed in treated alfalfa fields in several States. In California lowered populations were observed for 7 days following applications of a DDT-fused sulfur dust (Linsley *4*).

Despite the loss of bees from insecticide applications, with the subsequent increase in bloom the number of honey bee visitors to the field may exceed that before the dusting.

Benzene hexachloride and parathion are reported to be much more toxic than DDT to honey bees (Häfliger *2*). Investigations in Utah indicate that toxaphene is one of the least toxic of the new insecticides.

ROLE OF HONEY BEES IN SETTING PODS

In collecting nectar most bees reach into the flower through the side openings. In following a bee in the field one seldom finds more than 1 or 2 blossoms tripped out of every 100 that the bee has visited. Some bees, however, insert their mouth parts into the flower throat instead of at the side, and these bees have been observed to trip many of the flowers visited. In September 1944 a plot of 10 square yards in a field near Logan, Utah, was closely watched throughout the day. Nectar-collecting honey bees were active continuously, and at times 20 to 30 were present. No other bees were seen in the plot. By evening 18 percent of the blossoms had been tripped.

In various fields in Nebraska and Iowa, Drake (*1*) found 2 to 15 honey bees per square yard working on alfalfa in full bloom. Individual bees were observed to trip 8 percent of the flowers visited. In cage tests at Davis, Calif., honey bees tripped practically all the flowers each day.

At Knights Landing, Calif., in 1947 a seed crop (recleaned) of 560 pounds per acre in a 160-acre field was set almost entirely by honey bees in about 2 months. The bees were trucked into the field beginning June 8 (fig. 3). Observations on June 6 showed 1 honey bee for each 10 square yards and that 1.1 percent of the flowers had been tripped. On June 10 there were 24 honey bees in 10 square yards and 8 percent of the flowers had been tripped; 2 weeks later 30 honey bees in the same area had tripped 11 percent of the blossoms. During observations on 15 dates between May 15 and July 22 few pollen-collecting honey bees or wild bees were seen. Honey bees taken with sweep nets were also nearly all nectar gatherers.

In the same year at Ryer Island, Calif., honey bees were placed around 260 acres of seed alfalfa at the rate of three colonies per acre. Many nectar-collecting honey bees and a few wild bees were observed on the blossoms, but almost no pollen-collecting honey bees. A week's collection in a pollen trap on one hive was free of alfalfa pollen. The yield of thresher-run seed from the largest field (200 acres) was 550 pounds per acre.

In 1949 a large field at Davis produced 1,120 pounds of thresher-run seed. Honey bees from five or more colonies per acre provided the pollination. Most of these bees were nectar collectors, although alfalfa pollen was found in some of the traps.

Alfalfa-seed field with a row of colonies placed in groups of two. There were three rows across the field.

RELATION BETWEEN NUMBER OF COLONIES AND SEED YIELD

Evidence that the yield of alfalfa seed is related directly to the number of honey bee colonies in the vicinity is given in table 1, which shows the number of colonies and yields over a 5-year period in the Delta tract of Millard County, Utah. Wild bees are now scarce in this old and important seed area. Similar data for 1947 and 1948 in some California locations are presented in table 2.

TABLE 1.—*Relation between the number of colonies of honey bees in Delta, Utah, area and alfalfa-seed yield*

Year	Colonies	Seed yield per acre
	Thousands	*Pounds*
1943	8. 2	96
1944	7. 9	72
1945	6. 9	60
1946	11. 1	168
1947	9. 7	120

TABLE 2.—*Relation between the number of bee colonies per acre and the alfalfa-seed yield in California*

Location	Year	Size of field	Colonies per acre	Seed yield per acre [1]
		Acres	*Number*	*Pounds*
Knights Landing	1948	160	2. 5+	400
	1947	160	3+	560
Rio Vista	1948	200	3	[2] 350
	1947	300	3	400
Hemet	1948	95	3	540
		(?)	5	[3] 1, 000
Button Willow	1948	(?)	5	[3] 1, 000
Williams	1948	100	3+	[4] 650

[1] Recleaned seed unless otherwise indicated.
[2] Yield reduced by rain; a portion harvested before rain yielded 700 lb. of thresher-run seed.
[3] Verbal report by a seed grower.
[4] Thresher-run.

HONEY PRODUCTION FROM SEED ALFALFA

Alfalfa grown for seed is one of the leading honey plants west of the Missouri River. However, like all other honey plants, it gives a variable yield of honey. Table 3 shows that in California the yield varied from one locality to another, and even in different fields at Davis. At Rio Vista the production was much greater in 1948 than in 1949. The average production for 4,270 colonies in the 2 years was 40 pounds per colony.

TABLE 3.—*Honey yields from seed alfalfa in various locations in California*

Locality and year	Size of field	Honey produced per colony
1948	*Acres*	*Pounds*
Hemet	100	0
Knights Landing	160	20
Rio Vista [1]	200	200
1949		
Knights Landing	300	20
Rio Vista	200	35
Woodland	90	40
	40	0
Davis	132	10
	12	35

[1] About 1,000 acres of alfalfa hay were cut in this locality. Part of crop blossomed freely in 1948.

HOW TO IMPROVE POLLINATION BY HONEY BEES

We do not yet know how to obtain the maximum pollination from honey bees. Bee-management procedures have been directed almost entirely toward maximum honey production. We do know, however, that the placement of bees, as to both location and time, is important in the pollination of alfalfa blossoms. Observations of heaviest seed set near the colonies have led to their placement within the field. On Ryer Island, Calif., in 1947, for example, an especially heavy set was obtained from plants within 100 yards of the colonies, the yields being 30 percent greater than from plants 1,000 feet farther away.

At Davis honey bees were placed in an alfalfa field after a second crop had come into bloom late in August. A heavy population of bees, about 4 per square yard, was noted on the blossoms for the first 3 days, but after that, as the bees became oriented to their new environment and flew farther afield, the numbers diminished rapidly. At the end of 8 days these colonies were replaced by others, which acted similarly. In 16 days a good set of seed was obtained. Before the bees were brought in, from 1 to 4 percent of the blossoms were tripped daily, but thereafter the number increased to 12 to 40 percent.

Until more is known about how to stimulate the pollen-collecting activity of honey bees, the most feasible means of increasing seed production is to increase the number of colonies per acre and scatter them throughout the field. This practice is not profitable from the standpoint of honey production, however, as for this purpose beekeepers usually bring in one colony or less per acre of alfalfa. If they furnish more bees so that seed yields will be higher, some means should be found to compensate them for the loss of honey.

According to surveys in California, in a well-managed field having good soil and ample moisture it is not uncommon to obtain 150 or more pounds of alfalfa seed per acre with the service of each bee colony. On this basis the number of colonies needed to obtain 1,000 pounds of seed per acre is much larger than the average number now used.

POLLINATION SERVICE TO SEED GROWERS

In the West many honey bee colonies are trucked from place to place to take advantage of different honey sources. Getting them into the right place at the right time for crop pollination presents problems. The location with respect to sources of both pollen and nectar, the use of insecticides, the distance they must be moved, costs, and other factors must be considered. In deciduous fruit orchards in northern California, bees are easily obtained by rental, because the fruit trees blossom early and provide much pollen before the principal honey plants bloom. With alfalfa the problem is greater because it is a poor source of pollen. When the bees are needed in the seed fields of the lower Sacramento Valley, many colonies have already been moved to the thistle-growing area farther north, which is more dependable for nectar. The yellow star-thistle, also an excellent source of pollen, begins to blossom freely in June at the time of the second cutting of alfalfa.

Seed growers may obtain honey bee colonies by providing a location close to a source of nectar or pollen, by rental, or by purchase. Another plan, which is still in the experimental stage, is the cooperative sharing of the benefit of the bees' activity. With the greater recognition by alfalfa-seed growers of the part bees play in seed setting, efforts are being made to establish a sound basis for insuring their presence in sufficient numbers to provide a maximum seed crop and at the same time to give adequate compensation to the beekeeper. A few instances of such cooperation are presented.

In 1948 a grower of alfalfa seed at Hemet, Calif., contracted to pay a beekeeper 1 cent per colony for each pound of salable, or recleaned, seed in excess of 400 pounds per acre. The colonies were placed in small groups in three roadways across the field. The crop averaged 540 pounds of recleaned seed per acre, and the beekeeper received $1.40 per colony. Sixty pounds of honey, the long-time average per colony in California, at 10 cents a pound would have grossed $6. The 275 colonies placed on the 95 acres showed no gain in weight while working the alfalfa.

An alfalfa-hay producer at Davis, Calif., operated a 132-acre irrigated field for seed production in 1949 on an experimental cooperative basis. A beekeeper provided about six colonies per acre, moving them into the field in scattered locations on different dates. Tripping of blossoms increased promptly around newly established colonies, and the yield of thresher-run seed was 1,120 pounds per acre. The agreement called for two colonies per acre entirely free and for each of three other colonies $1 in rental and 1 cent for each pound of recleaned seed in excess of 400 pounds per acre. The beekeeper received $17.90 per acre for the pollination service, but the honey yield was only 10 pounds per colony.

The following rental agreements between beekeeper and seed growers have also been tried in California:

Agreement:	*Number of colonies per acre furnished seed grower*	*Payment to beekeeper in addition to apiary location*
1	2	Nothing.
2	5	Nothing.
3	4	$1 per colony.
4	4	$2 per colony.
5	3½	60 pounds of honey per colony.
6	3	1 cent per colony for each pound of recleaned seed in excess of 400 pounds per acre.
7	5	Same as agreement 6 plus $1 rental on each of 3 colonies per acre.

In these fields the production of thresher-run seed ranged from about 250 to 1,120 pounds per acre. Recleaning reduces the yield by about 10 to 20 percent.

From the experience of these and other beekeepers in supplying pollination service in honey bees, three conclusions have been drawn:

(1) More colonies are required for adequate pollination than the alfalfa honey flow will support.

(2) The beekeeper's compensation per colony must at least equal that from a good honey crop.

(3) For pollination service requiring a large number of colonies, the seed grower should pay the beekeeper cash or a share of the crop.

SUMMARY

The production of alfalfa seed in the West is becoming increasingly dependent on honey bees (*Apis mellifera* L.) as pollinating agents. Wild bees were formerly considered more efficient for this purpose, but their numbers have been greatly reduced by modern agricultural practices, with consequent decline in seed production. Research conducted in recent years has shown clearly the role of honey bees as pollinating agents and the feasibility of increasing seed production through their use.

It is evident that pollination must be planned for in the same manner as other crop needs. The only practicable means of providing adequate pollination is to place honey bee colonies in the alfalfa field at blossoming time. Since this practice is not profitable from the standpoint of honey production, some means of compensating beekeepers for providing pollination service to seed growers is desirable. Both rental and cooperative types of agreements between growers and beekeepers are being developed.

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